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ADVANCED MODELING OF ELECTRO-ENERGETIC DEVICES

JOHN VERBONCOEUR

REGENTS OF THE UNIVERSITY OF CALIFORNIA, THE

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Final Report

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AF OFFICE OF SCIENTIFIC RESEARCH (AFOSR)/RSE
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14. ABSTRACT

The goal of the project was the development of a state of the art code suite in 1D-3D, based on the object-oriented paradigm pioneered in the XOOPIC code, supported in the previous decade by AFOSR. Advances planned included massively parallel computing capability, a programmable front-end for controlling the code using the Python language, and a backend diagnostic and plotting package based on Python. Planned physical models included improved boundary conditions, including conformal boundary capability, uniformity and extension from 1D to 3D, and many improved physics capabilities aimed at microwave sources and high pressure plasmas.

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Advanced Modeling of Electro-Energetic Devices

Principle Investigator: John Verboncoeur

Address: Dept. Electrical and Computer Engineering, Michigan State University, East Lansing, MI 48824 (formerly University of California at Berkeley)

Executive Summary

The project was initiated in mid-2009 at the University of California at Berkeley (UCB), while the Principle Investigator was a Professor in the Department of Nuclear Engineering at UCB. The grant was canceled at the end of 2011 after the PI moved to the Department of Electrical and Computer Engineering at Michigan State University (MSU), after unsuccessful attempts to transfer the grant. Part of the funds in the final year were transferred to MSU during a no-cost extension, in the hope of continuing the work there. Attempts to re-propose the final 3 years of the grant at MSU were not successful.

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Given the shortened time horizon of the grant, the initial efforts focused on the Python input, control, diagnostics, and plotting, field and space charge emission physics models, improved emission boundary conditions, with applications to space charge flow. In particular, work on the parallel and 3D models could not be completed within the shortened time frame.

The accomplishments include the following:

- Python input interface in 1D and 2D. This input interface allows the specification of arbitrary equations, data tables, and other features using the Python language. Examples including setting up arbitrary diode voltage as a function of time.
- Python wrapper to allow real time control of simulation, including specifying criteria for advancing, variable time steps, context sensitive algorithms, and the ability back up, branch, and compare different algorithms run from the same point.
- Python wrapping of a number of internal variables to allow run-time construction of diagnostics, including the calculation of diagnostics from combinations of fundamental quantities.
- Python capability to plot diagnostics in real time.
- Improved emission algorithm to better account for edge and corner effects in emitters, considering charge weighted back to nodes and the associated fields.

Publications

B. Ragan-Kelley and J. P. Verboncoeur, "Relaxing Assumptions in Field-Limited Emission, and an Iterative Approach to the Axisymmetric Scaling Law", in preparation.

B. Ragan-Kelley, J. P. Verboncoeur, and M. C. Lin "Optimizing Physical Parameters in 1-D Particle-in-Cell Simulations with Python", submitted to Comp. Physics Comm. (2013).

M. C. Lin, P. S. Lu, P. C. Chang, B. Ragan-Kelley, and J. P. Verboncoeur, "A relativistic self-consistent model for studying enhancement of space charge limited field emission due to counter-streaming ions", submitted to Phys. Plasmas (2013).

B. Ragan-Kelley, "Explorations of Space-Charge Limits in Parallel-Plate Diodes and Associated Techniques for Automation", PhD Thesis, University of California – Berkeley (2013).

B. Ragan-Kelley, J. Verboncoeur, and Y. Feng, "Two-dimensional axisymmetric Child--Langmuir scaling law", Phys. Plasmas 16, 103102 (2009).

B. Ragan-Kelley and J. Verboncoeur, "Relaxing Assumptions in Field-Limited Emission, and an Iterative Approach to a Scaling Law for Space-Charge Limited Flow in Axisymmetric 2D", 2013 IEEE PPPS, San Francisco, CA USA (2013).

B. Ragan-Kelley, J. Verboncoeur, and M.-C. Lin, "Programmable physical parameter optimization for particle plasma simulations", Bull. Am. Phys. Soc. 57:12, UP8.00008 (2012).

B. Ragan-Kelley and J. Verboncoeur, "Interactive, Extensible PIC Simulations with a Python Interface", Bull. Am. Phys. Soc. 56, NP9.00030 (2011).